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the small spots) was the same as that of the large spot. All of the small spots, however, were of opposite polarity. Between the large and small spots the magnetic fields of opposite polarity counteracted one another, reducing the strength of the resultant field to zero. This is shown on the photographs by the form of the lines: the red components bend sharply back from the position of maximum displacement over the large spot to the normal position of the line, where they cross to the violet side, returning again to normal in the region beyond the small spots.

By means of a series of parallel slits, the spectra of from six to ten sections of a spot group can be photographed simultaneously, in parallel strips on a single negative. A simple apparatus then permits images of any desired line in this negative to be photographed side by side, in the same relative positions as the parallel slits of the spectrograph. A photograph of the hydrogen flocculi, made with the  $H\alpha$  line, is then copied on the same plate.<sup>1</sup> The composite image shows the strength and polarity<sup>2</sup> of the magnetic fields along the lines occupied by the slits, and permits the relationship between the magnetic fields and the curvature of the streamers in the  $H\alpha$  vortices to be investigated. Results already obtained with provisional apparatus show this relationship to be an intimate one.

GEORGE E. HALE.

#### SPECTROGRAPHIC AND PHOTOGRAPHIC OBSERVATIONS OF COMET c 1908 (MOREHOUSE).<sup>3</sup>

So exceedingly faint was the nucleus of this comet that great difficulty was experienced in securing a slit spectrogram. An exposure was finally made with the one-prism spectrograph of the D. O. Mills Expedition extending over seven hours and twenty-nine minutes on the nights of February 24, 25, and 26, 1909. The width of the slit was 0.5<sup>mm</sup> and precautions were taken to keep the temperature of the

<sup>1</sup> Perfect registration is readily secured by the aid of a photograph of the spot group, reflected from the polished slit jaws into a camera, showing the exact positions of the slits with reference to the spots.

<sup>2</sup> With high dispersion the direction of the field can also be determined by the intensity of the central line of a triplet.

<sup>3</sup> Abstract of *Lick Observatory Bulletin*, No. 163.

prism at the same point during all three exposure epochs and for several hours before commencing work. Only the strongest of the pairs, that at  $\lambda 4255.76$ , can be made out on this plate, and the resulting wave-lengths are  $\lambda 4254.2$  and  $\lambda 4275.4$ .

Between February 24th and March 23d seventeen objective-prism spectrograms of the comet were secured, nearly all of them very faint. The resulting wave-lengths are:—

|   |           |                |
|---|-----------|----------------|
| $\lambda 3914.1$  | 9 plates  |                |
| $\left. \begin{array}{l} 4002.1 \\ 4021.3 \end{array} \right\}$   | 15 plates |                |
| $\left. \begin{array}{l} 4254.0 \\ (4276.0) \end{array} \right\}$ | 17 plates |                |
| $4526 \pm$  | 3 plates  | Very difficult |
| $\left. \begin{array}{l} 4545.9 \\ 4570.2 \end{array} \right\}$   | 16 plates |                |
| $\left. \begin{array}{l} 4690.7 \\ 4716.3 \end{array} \right\}$   | 4 plates  | Difficult      |

In determining the wave-lengths given above, the line at  $\lambda 4276.0$  was assumed as known.

Collecting the differences for the three strongest pairs of lines,  $\lambda 4002.21$ ,  $\lambda 4254.76$ ,  $\lambda 4546.70$ , together with the corresponding angles at the comet between the radius vector and the line connecting the comet with the Earth, we have:—

| Observer.                   | Date.        | $\Delta\lambda_1$ | $\Delta\lambda_2$ | $\Delta\lambda_3$ | Angle.       |
|-----------------------------|--------------|-------------------|-------------------|-------------------|--------------|
| DESLANDRES and BERNARD..... | 1908 Oct. 14 | 20                | 23                | $20 \pm$          | $39^\circ.9$ |
| DESLANDRES and BOSLER.....  | Nov. 1       | 19.7              | 21.6              | 22.0              | 46 .3        |
| CAMPBELL and ALBRECHT.....  | Nov. 28      | 19.6              | 20.7              | 20.8              | 37 .2        |
| CURTIS .....                | 1909 Feb. 25 | 18.5              | 22.0              | 24.5              | 39 .7        |
| CURTIS .....                | Mar. 21      | 19.4              | 22.5              | 23.8              | 35 .6        |

The objections to the explanation of the doubling of these lines as a Doppler-Fizeau effect have already been well put by CAMPBELL and ALBRECHT.<sup>1</sup> Assuming the actual velocities along the tail or transverse to the tail to have been the same on November 1, 1908, and March 21, 1909, the mean of the intervals for the three principal pairs of lines should have been about four tenth-meters greater, or less, respectively, on March 21st than on November 1st; whereas the observed

<sup>1</sup> cf. *Lick Observatory Bulletins*, 5, 64, 1909.

intervals are not quite one tenth-meter greater on the latter date.

The stronger objective-prism plates show the tail, though very faintly, to a distance of two to two and a half degrees from the head, and in all cases the tail is apparently a replica of the direct photographs taken at the same time, as far as can be made out on the small scale of the plates. In this respect a plate taken on March 20th is of especial interest; on this night the direct photograph shows a marked curve in the tail about half a degree from the head, a curve which is duplicated in each of the spectral images.

Twenty-eight direct photographs were also secured, the majority of these being taken with a portrait lens of  $6\frac{1}{8}$  inches aperture; many of these direct photographs show interesting evidences of the extraordinary activity which seems to have characterized this comet, both before and after perihelion.

HEBER D. CURTIS.

#### THIRTEEN STARS HAVING VARIABLE RADIAL VELOCITIES.<sup>1</sup>

In the progress of the work of the D. O. Mills Expedition to the southern hemisphere it has been found that the following stars have variable radial velocities:—

| Star.                 | $\alpha$                          | $\delta$  | Mag. | Type. | Range, km    | Discoverer. |
|-----------------------|-----------------------------------|-----------|------|-------|--------------|-------------|
| A.G.C. 8017           | 6 <sup>h</sup> 28 <sup>m</sup> .9 | — 31° 57' | 5.7  | B3A   | + 5 to + 41  | CURTIS      |
| A.G.C. 9276           | 7 13 .3                           | — 36 25   | 5.0  | B3A   | — 19 to + 41 | PADDOCK     |
| $\epsilon$ Volantis   | 8 7 .6                            | — 68 19   | 4.5  | B5A   | — 29 to + 45 | CURTIS      |
| H Vellorum            | 8 53 .3                           | — 52 21   | 4.8  | B5A   | — 4 to + 68  | PADDOCK     |
| $\beta$ Crateris      | 11 6 .7                           | — 22 17   | 4.5  | A2F   | — 7 to + 12  | PADDOCK     |
| A.G.C. 15975          | 11 36 .2                          | — 61 32   | 4.9  | G     | — 4 to + 23  | PADDOCK     |
| $\theta^2$ Crucis     | 11 59 .2                          | — 62 36   | 5.0  | B3A   | — 19 to + 47 | PADDOCK     |
| A.G.C. 19597          | 14 23 .7                          | — 49 4    | 5.5  | A2F   | Both spectra | CURTIS      |
| $\epsilon$ Lupi       | 15 6 .1                           | — 44 8    | 4.9  | B3A   | — 8 to + 29  | CURTIS      |
| $\zeta$ Trianguli     |                                   |           |      |       |              |             |
| Australis             | 16 17 .6                          | — 69 52   | 4.9  | G     | — 2 to + 17  | CURTIS      |
| $\delta^1$ Telescopii | 18 24 .4                          | — 45 59   | 5.0  | B8A   | — 72 to + 27 | CURTIS      |
| $\delta^2$ Telescopii | 18 24 .7                          | — 45 49   | 5.3  | B5A   | — 9 to — 29  | CURTIS      |
| $\iota$ Pisc.         |                                   |           |      |       |              |             |
| Australis             | 21 39 .0                          | — 33 29   | 4.4  | A     | Both spectra | CURTIS      |

With the exception of two plates on A.G.C. 15975, all the plates were taken with the two-prism spectrograph.

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<sup>1</sup> Abstract of *Lick Observatory Bulletin*, No. 164.